Space Weather Technical Forecast

Issued on Wednesday 8 January 2025 at 12:54 Local

This technical forecast provides a four-day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

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Space Weather Forecast Headline: Chance of isolated M-class flares. Active electron fluence expected Days 1 and 2 (08-09 Jan).

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Moderate with one long-duration M1.1 flare observed peaking at 07/2305 UTC, likely from AR3939 from just over the southwest limb. There are eight regions currently visible on the Earth-facing disc, with only one notable region AR3947, now approaching the north-centre disc. This remains moderately sized with a complex magnetic structure including a weak delta-spot amongst the intermediate portion of the group, although flare activity in the last 24 hours has significantly waned from previous days. AR3950 in the southeast, although small and magnetically simple, produced a C9.9 flare at 08/0637 UTC. The other regions across the disc are all small and simple, and either stable or showing signs of decay.

No Earth-directed CMEs were observed, with those visible in current imagery off the Earth-Sun line.

Solar Wind / Geomagnetic Activity: Ongoing fast wind from CH05/+ gradually eased after a weak and glancing CME arrival evident between 07/0430-1250 UTC, likely due to the passing of the shockwave of the eruption from AR3939 on 04 Jan. Solar wind speeds were initially elevated at 560-590km/s due to the glancing CME but quickly began to trend down, with speeds near 450km/s by the end of the period. The Interplanetary Magnetic Field, Bt, remained weak and steady around 5-6nT throughout. The north-south component, Bz, was variable between +/-5nT, but slightly favoured a southward direction from 07/1250 UTC. Phi angle was mostly positive (away from the Sun), but more variable initially during the CME passage. Geomagnetic activity was initially Quiet to Unsettled (Kp 2-3) with an Active (Kp4) interval between 08/0000-0300 UTC, then falling to Quiet.

Energetic Particles / Solar Radiation: High energy proton flux (greater than 10MeV) at GOES-18 was near background. High energy electron flux (greater than 2MeV) at GOES16 was initially High dropping to Moderate from 07/2315 UTC, peaking at 3070 pfu at 07/1850 UTC. The associated 24 hour fluence rose in response, to be just under the Active threshold by 08/0000 UTC, reaching 8.87e7 integrated pfu.

Four-Day Space Weather Forecast Summary

Solar Activity: Low to Moderate is expected with an ongoing chance of isolated M-class flares.

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Solar Wind / Geomagnetic Activity: There are no Earth-directed CME's. Current slightly elevated solar winds from CH05/+ are expected to continue erratically easing through Days 1-2 (08-09 Jan) towards background, before a further brief enhancement is likely from CH07/+ fast winds on Days 3-4 (10-11 Jan). Geomagnetic activity is expected to be mostly Quiet with isolated Unsettled intervals. There is a chance of this increasing to Unsettled to Active with a slight chance of G1/Minor Storm intervals with the fast wind onset.

Energetic Particles / Solar Radiation: GOES18 high energy proton flux is near background with a slight chance of further Solar Radiation Storms as AR3947 moves into the western hemisphere. GOES 16 high energy electron flux is forecast to continue at Moderate to High, perhaps becoming mainly High with the associated 24 hour fluence expected to rise above the Active level on Day 1 (08 Jan). This is likely to persist at this level, but with a decreasing confidence, especially from Day 3 (10 Jan) onward with any further fast wind onset.

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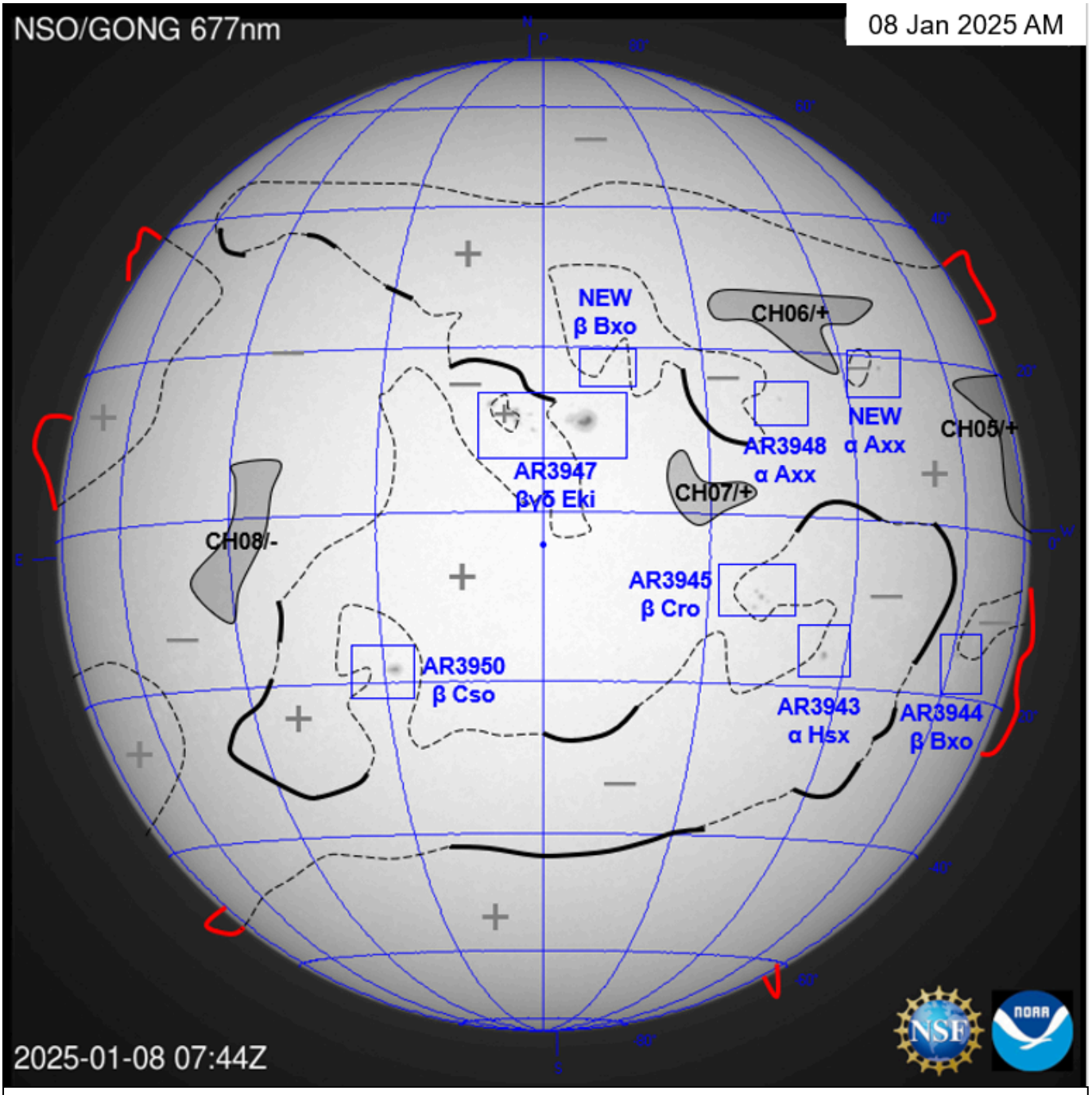
Figure 1: Solar Synoptic Map valid 08/0744 UTC



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms

There are no Earth-directed CMEs. The M4.8 flare at 06/1624 UTC from AR3947 produced an associated Type II radio emission, however no CME has been observed in coronagraph imagery. While uncertain, the Type II may have been a result of the observed EUV wave in the Sun's corona, which is observed in e.g. GOES SUVI 195 imagery, rather than the successful generation of a CME. Any material released is now considered too minimal to have an influence on this forecast. Following this, the M1.1 flare at 07/2300 UTC from the southwest limb, most likely associated with AR3939 appears to be too far west to see any material directed towards the Earth. At around 08/0030 UTC a faint prominence can be seen lifting from the northeast, this appears to be relatively slow and is expected to pass behind Earths orbit, although we are waiting on further model data to confirm.

Solar winds are currently easing after being connected to the fast wind of CH05/+, and this erratic decline in wind speeds is expected to continue through Days 1-2 (08-09 Jan) as solar winds ease. There are a number of other small coronal holes on the disc, however the only feature that is likely to influence Earth is CH07/-. This is a small feature, with its weak fast wind likely to move through on Days 3-4 (10-11 Jan), perhaps bringing a brief increase to solar winds, to around 450km/s. This is similar to the previous rotation, as while the coronal hole is smaller on this occasion, this does not always correspond to the observed speed of the fast wind at Earth. CH06/+ in the northwest is likely too far north to have an influence on the Earth. MOSWOC Enlil output is viewed with reasonable confidence in the gradual easing of the fast winds from CH05/+, but perhaps too slow to bringing in any influence from CH07/-.

Geomagnetic activity is expected to be mostly Quiet with isolated Unsettled intervals. There is a chance of this increasing to Unsettled to Active with a slight chance of G1/Minor Storm intervals with CH07/+ onset Days 3-4 (10-11 Jan).

Geomagnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	**G1 to G2**	No	1	1	5	5
Strong	**G3**	No	1	1	1	1
Severe	**G4**	No	1	1	1	1
Extreme	**G5**	No	1	1	1	1

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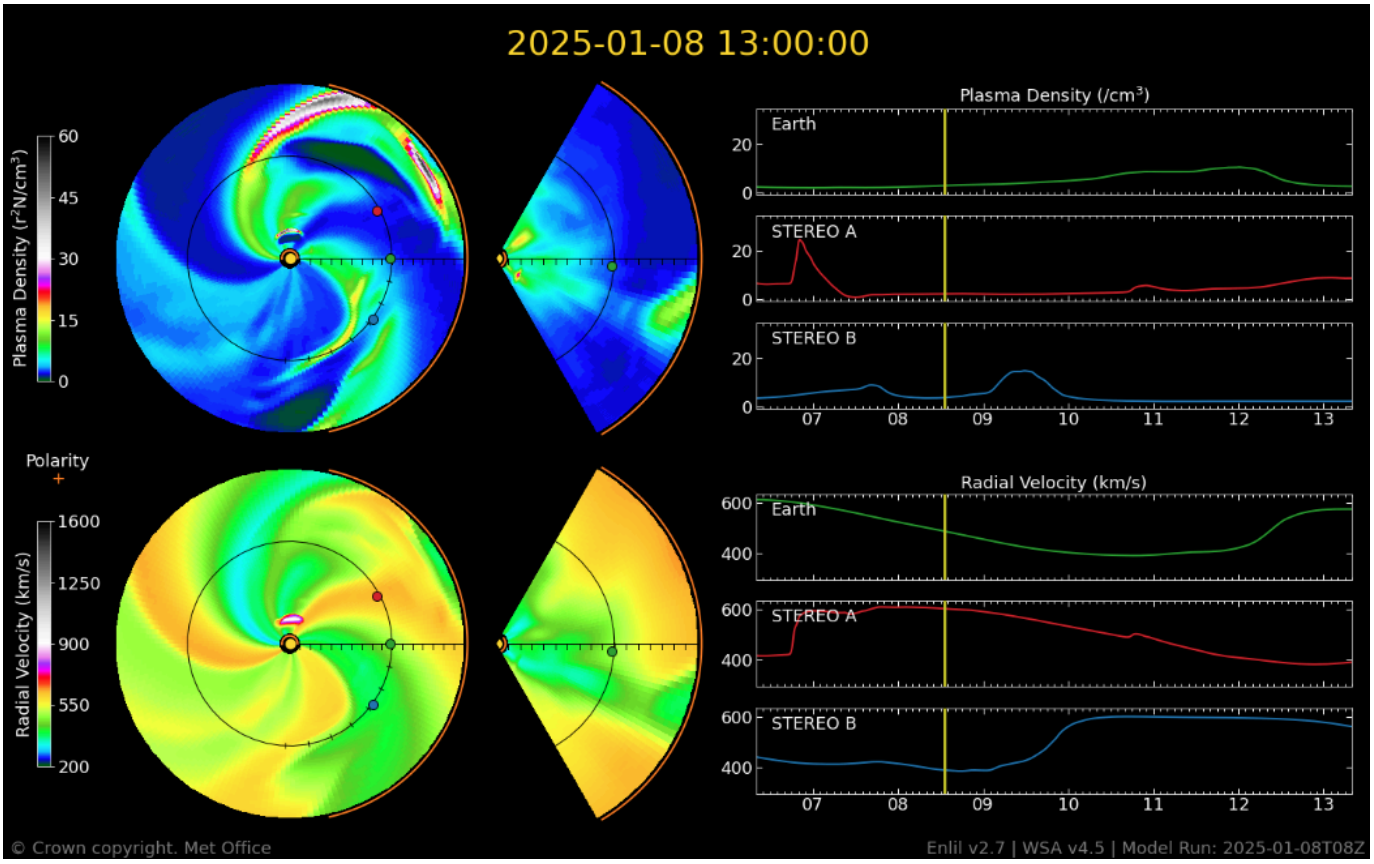
Figure 2: MOSWOC Enlil output showing the gradual decline in solar wind speed.



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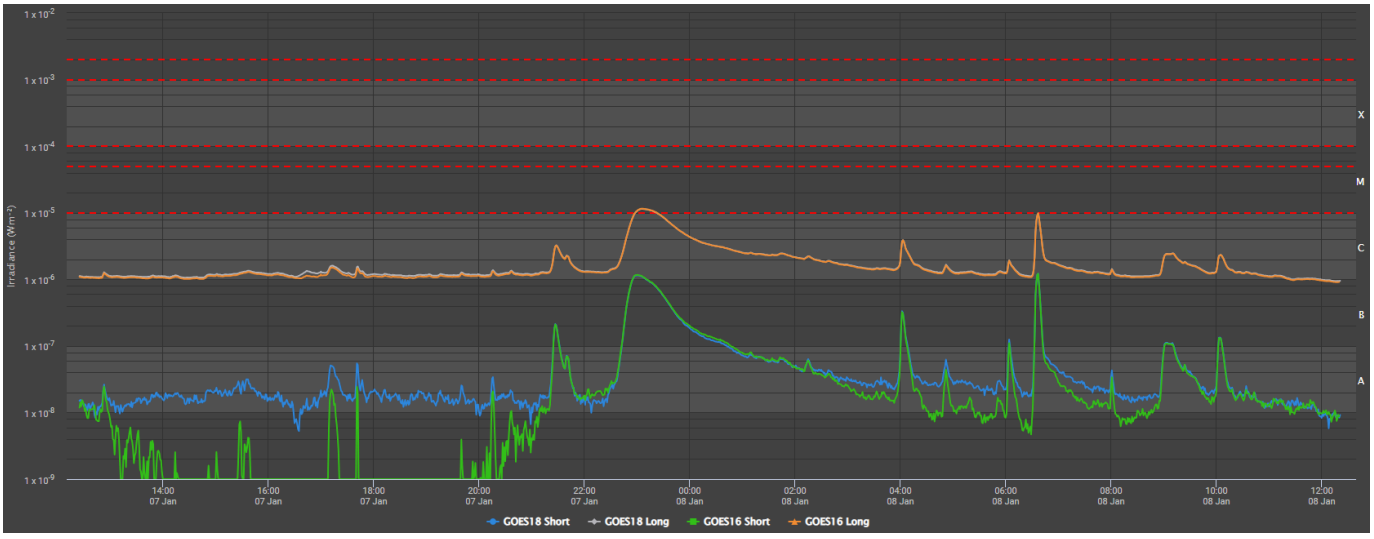
Radio Blackouts - X-Ray Flares

Low to Moderate activity is expected with a chance of isolated M-class flares possible, mainly from AR3947, which is the only notable sunspot group of the eight currently on the Earth-facing disc.

AR3947 has been the source of much of the recent activity, including the X-class flares on the previous days, the region remains moderately sized with a complex magnetic structure including a weak delta-spot amongst the intermediate portion of the group. Although this has been difficult to confidently identify due to its weak appearance. However activity from this region in the last 24 hours has some what dwindled. The peak M1.1 flare at 07/2307 UTC appears to have originated from the southwest limb, most likely from AR3939. The next largest flare, was a C9.9 flare at 08/0637 UTC from AR3950, a small, and magnetically simple Cso group in the southeast. Across the rest of the disc, the other regions are all very small and simple, and either stable or showing some sign of decay.

X-Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 (M Class)	Yes	50	50	50	50
Very Active	R3-R5 (X Class)	No	10	10	10	10

Figure 3: GOES16 &18 X-ray flare trace.



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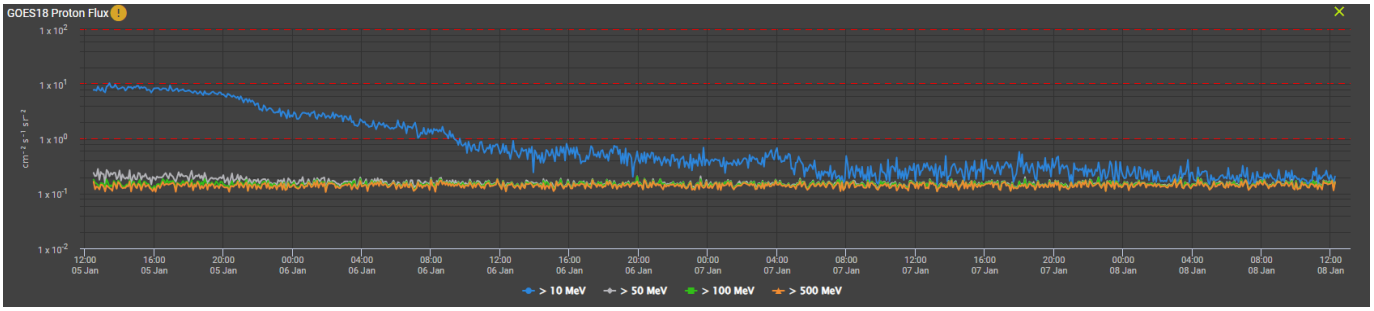
Solar Radiation Storms (High Energy Protons)

GOES18 high energy proton flux is now near background, having eased after the recent enhancement. The source of this enhancement AR3939 is now onto the far-side, with a decreasing potential to erupt high energy protons that can be observed at Earth. However a slight chance of further enhancement is maintained due AR3947 which is now approaching the centre disc. While its shown a reduction in activity in the last 24 hours, this will continue to provide a chance of further flares as this moves into the western hemisphere, which is better connected for observable high energy protons at Earth. Furthermore, there are a number of filaments currently on the western disc, and it is not impossible that a large eruption from any of these could result in Earth-directed high energy protons.

Radiation Storms Probability (Exceedance)	Level ($cm^{-2}sr^{-1}s^{-1}$)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	10	10	10	10
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and/or 50 MeV ≥ 10pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

Figure 4: GOES 18 Proton Flux since 05/1200 UTC showing a gradual decline.



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High Energy Electrons (≥ 2MeV)

High energy electron flux observed at GOES16 climbed from Moderate to mainly High values. This is as a result of solar winds now gradually easing, after the combined effect of the fast wind enhancement from CH05 and recent weak glancing CMEs. This sequence of events would have led to the charging of the Van Allen Belts, albeit at lower orbital levels, and then as solar winds ease, the radiation belts have then expanded back to incorporate GEO. Subsequently the observed flux has risen, and is likely to remain at moderate to diurnally high for much of the period. The main suppression is likely to come from any weak influence of the fast wind from CH07, most likely on Day 3 (10 Jan).

Fluence is currently near the Active threshold, and with a rising trend. This is expected to soon rise above the Active threshold on Day 1 (08 Jan), with a decreasing confidence of then persisting above, especially Day 3 (10 Jan) onward due to any potential fast wind onset. This rising trend is supported by REFM, however this is currently slightly underestimating expected values.

GEO Electron Environment	Level ($cm^{-2}sr^{-1}$ day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ 2 MeV ≥ 1×10^{8}	No	80	80	50	30
Very Active	≥ 2 MeV ≥ 1×10^{9}	No	1	1	1	1

Figure 5: GOES 16 Electron Flux showing Moderate levels peaking in the diurnal cycle to High since 05/1200 UTC.

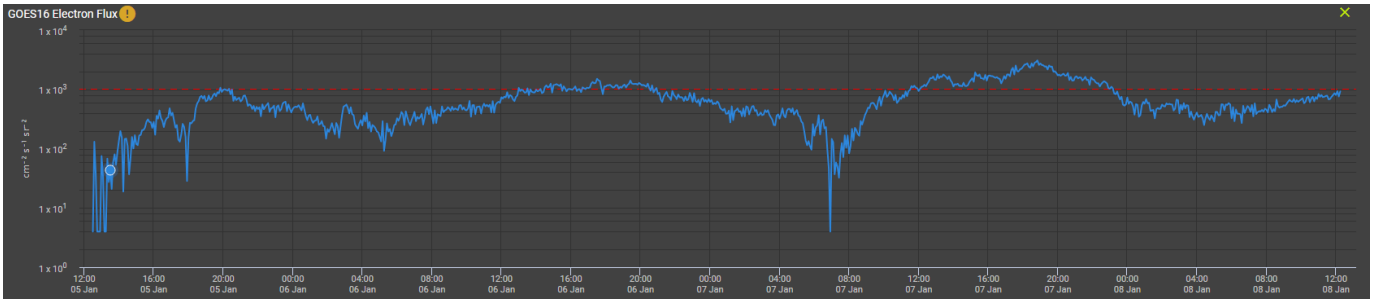

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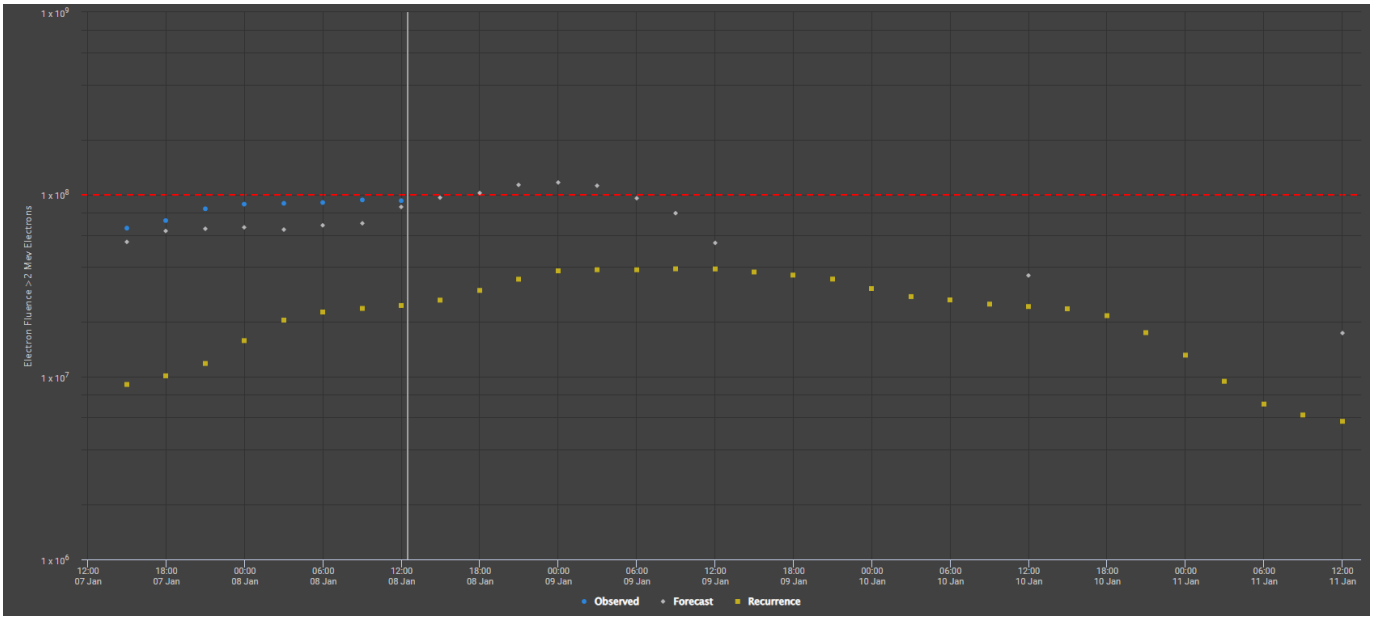
Figure 6: MOSWOC REFM output showing an increasing trend, rising above the Active threshold by 08/1800 UTC.



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